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IS 12888 (1989): Optical and Mathematical Instruments -
Short Range Infrared Distance Measuring Instruments [PGD
22: Educational Instruments and Equipment]



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“Knowledge is such a treasure which cannot be stolen”

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Indian Standard

**OPTICAL AND MATHEMATICAL
INSTRUMENTS — SHORT RANGE INFRARED
DISTANCE MEASURING INSTRUMENTS —
SPECIFICATION**

भारतीय मानक

प्रकाशिक एवं गणितीय उपकरण — लघुपरास अवरक्त दूरी मापन उपकरण — विशिष्ट

UDC 528'514 : 681'75

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NEW DELHI 110002

August 1990

Price Group 4

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards on 17 November 1989, after the draft finalized by the Optical and Mathematical Instruments Sectional Committee had been approved by the Light Mechanical Engineering Division Council.

Distance measurement on the surface of the earth has been in use since long. Except invar wires, other mechanical devices are not capable of measuring distances with good accuracy. Besides, due to short lengths of these devices, longer distances cannot be measured rapidly. Invar wires, though very accurate, involve laborious drill and take enough time to measure even short distances. These problems have now been solved by using electromagnetic distance measuring (EDM) instruments which are accurate as well as capable of measuring considerable distances within short times.

EDM instruments use microwave, infrared or visible light as carrier wave and accordingly they have been named. Some of them are capable of measuring long distances while some can measure only short distance. Instruments measuring short distances generally use infrared and are, therefore, called short range infrared distance measuring instruments.

This instrument consists of a transmitting and a receiving system (Fig. 1 and 2). The infrared radiation is emitted by the gallium arsenide diode which is operated with measuring wave frequencies produced by quartz crystals. The emitted carrier infrared radiation is, therefore, automatically modulated by measuring waves. This radiation is transmitted out as parallel beam by the transmitting lens system (optics) of the instrument. The retro-reflector (corner cube prism), placed at the other end of the distance, reflects modulated infrared beam into the receiving system of the instrument. The receiving optics focusses the infrared beam on to a photodiode which converts it into electrical form. The phase difference between transmitted and received measuring waves is measured which gives the distance. The transmitting and receiving systems are placed either parallel to each other or are co-axial. These, together with gallium arsenide diode, photodiode and electronic system, etc, are contained in a mechanical housing. This housing also carries the front panel, displays, various switches and meters, etc. A sighting telescope is fitted with this housing for locating the distant reflector. The housing is mounted on a theodolite or the systems contained in it can form integral part of the theodolite. A battery is used to operate this instrument.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

OPTICAL AND MATHEMATICAL INSTRUMENTS — SHORT RANGE INFRARED DISTANCE MEASURING INSTRUMENTS— SPECIFICATION

1 SCOPE

1.1 This standard covers the requirements of short range infrared distance measuring instrument used for measuring distances up to 2 km.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard :

<i>IS No.</i>	<i>Title</i>
988 : 1959	General requirement for optical components
1399 : 1959	Glossary of terms used in optical technology
10236	Procedure for basic climatic and durability tests for optical instruments :
(Part 2) : 1982	Dry heat test
(Part 3) : 1982	Cold test
(Part 6) : 1982	Salt mist test
(Part 11) : 1985	Vibration test
(Part 14) : 1986	Driving rain test

3 TERMINOLOGY

3.1 For the purpose of this standard, the definitions given in IS 1399 : 1959 and the following definitions shall apply.

3.2 Carrier Wave

The wave which carries measuring/modulation wave. In these instruments, infrared works as carrier wave. The wave length is around 0.9 micron.

3.3 Co-axial System

The system in which the transmitting and receiving optical systems are placed on the same axis (Fig. 1).

3.4 Collimation Error

The error caused due to lack of parallelism between distance measuring instrument and theodolite when the former is mounted over the latter. This is due to improper fitting between the two and occurs in separate systems. This error makes alignment of the instrument on the reflector difficult and sometimes even impossible.

3.5 External Attenuator Screen

It is a plastic mesh fitted or moulded with a plastic/metal frame. It is to be fitted over the objective lens to attenuate the infrared (IR) signal while measuring very short distance.

3.6 Front Panel

It contains a display (LCD/LED) and control

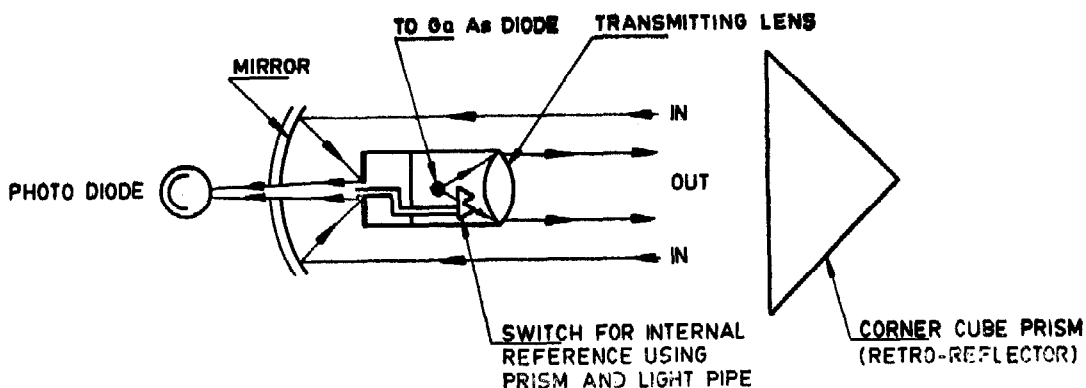


FIG. 1 CO-AXIAL SYSTEM

switches (membrane/touch type or electromechanical) to ensure operation by the operator.

3.7 Gallium Arsenide Diode

A semiconductor diode which emits infrared radiation (Fig. 1 and 3).

3.8 Integrated System

An EDM instrument combined with a theodolite such that the whole system is integrated together and cannot be separated (Fig. 2).

3.9 Measuring/Modulating Wave

The wave produced by crystal oscillators in the instrument to measure the distance. It modulates the carrier infrared and is, therefore, also known as modulating wave.

3.10 Parallel System

The system in which the transmitting and receiving optical systems are placed parallel to each other (Fig. 3).

3.11 Photodiode

A semiconductor type of photocell in which the

incident light controls the current flow between the electrodes. This component converts the infrared into electrical form, after being reflected and received from the reflector (Fig. 1 and 3).

3.12 Power Switch

An OFF/ON switch to connect the main instrument to the battery through a cable.

3.13 ppm

This is abbreviated form of parts per million. An accuracy of 1 ppm means an accuracy of 1 mm at 1 km (10^6 or 1 million mm).

3.14 Rain and Dust Cover

It is a plastic jacket to protect IR distancer from light, rain and dust while the instrument is not in use in the field.

3.15 Retro-Reflector/Prism

This is a corner cube prism used for reflecting infrared. In this prism, three surfaces meet at right angles at the corner and reflect the beam in the incident direction (Fig. 4).

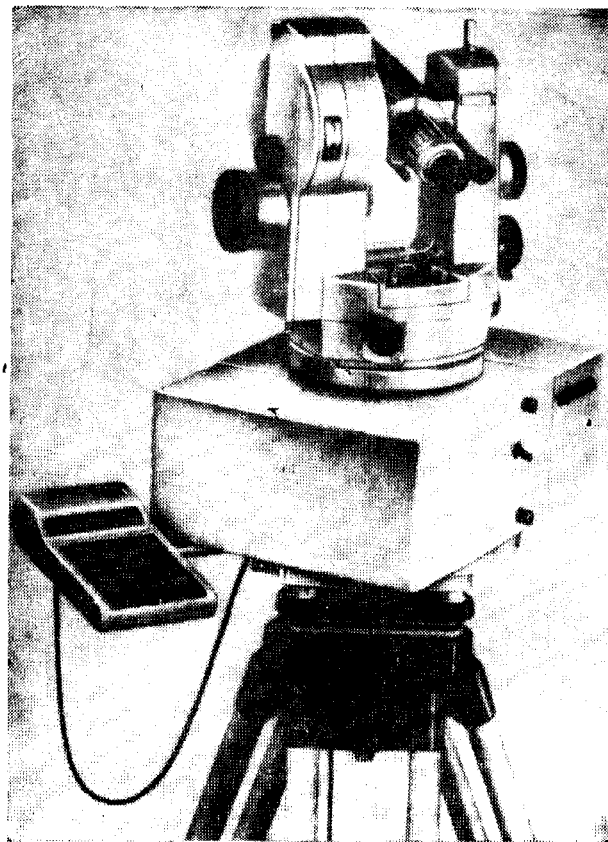


FIG. 2 INTEGRATED SYSTEM

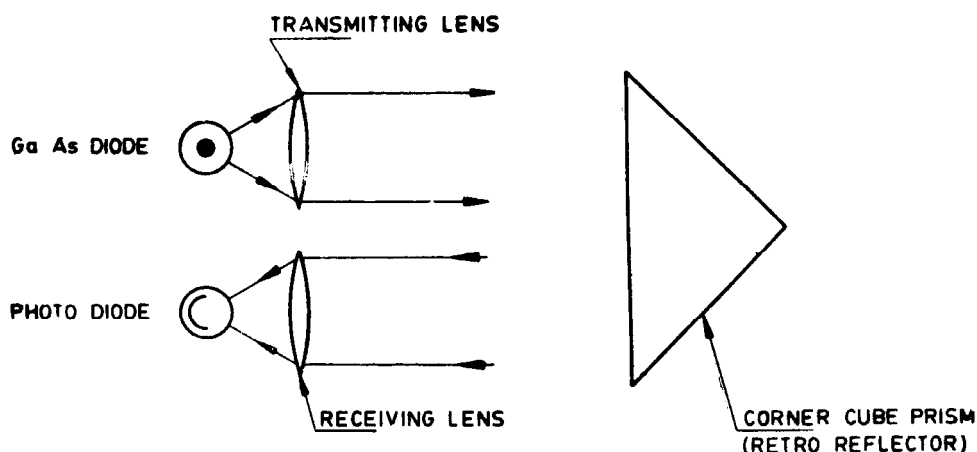


FIG. 3 PARALLEL SYSTEM

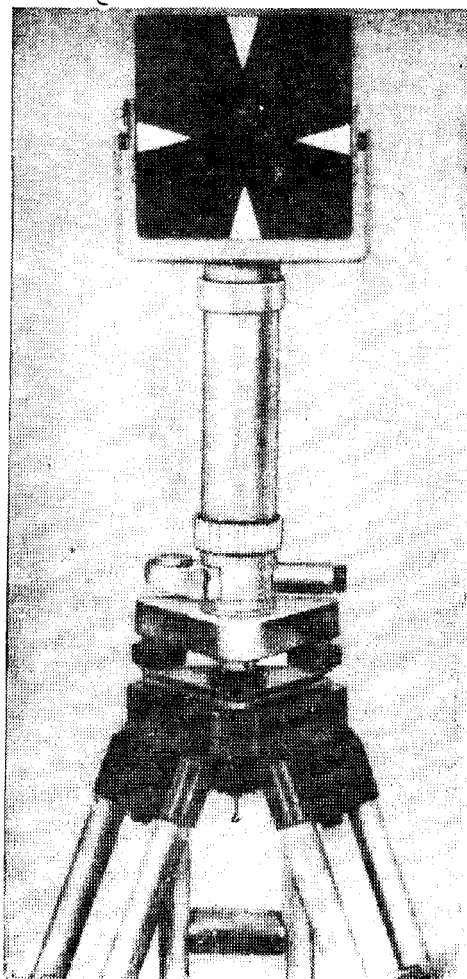


FIG. 4 RETRO-REFLECTOR

3.16 Separate System

The system in which EDM is separated with theodolite and the former is mounted over the latter with the help of adapter (Fig. 5A, 5B and 5C).

3.17 Transmitting/Receiving Systems

The optical systems which transmit collimated infrared to retro-reflector and receive the reflected beam to focus at the photodiode. Either two similar lens systems, placed parallel to each other, can be used for transmitting and receiving or they can be placed on the same axis.

3.18 Tribrach

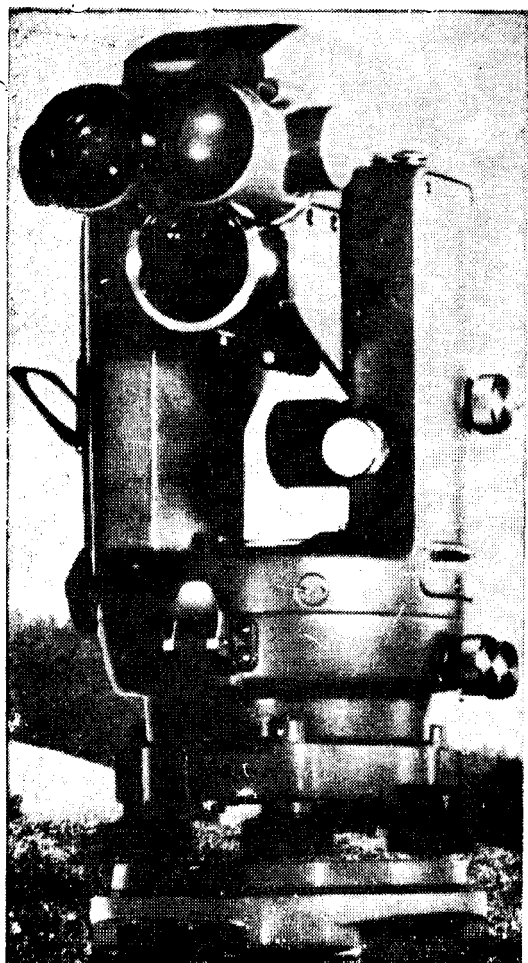
A mechanical device to hold the retro-reflector (prism) or theodolite on the tripod. It is provided with an optical plummet for centring on ground.

3.19 Wrapper

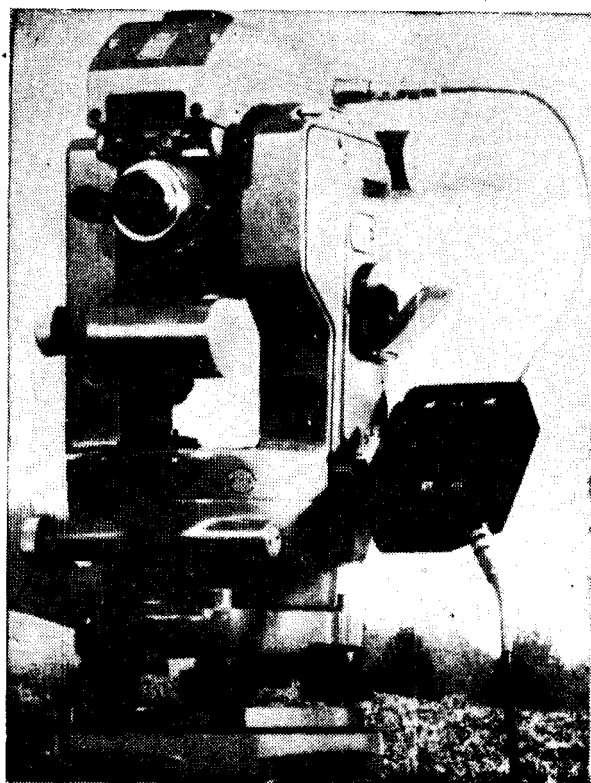
A weather resistant casing of the instrument to protect internal opto-electronic components against adverse atmospheric conditions and climatic conditions.

3.20 Yoke

A mechanical fixture, in U-shape, to hold the instrument with the theodolite or tribrach. The provision for horizontal and vertical movements for IR distance are provided in this yoke. A sighting telescope is also provided to locate the retro-reflector.



(a) Front Side



(b) Back Side



(c) Back Side

FIG. 5 SEPARATE SYSTEM

3.21 Zero-Error (Additive Constant)

The separation between mechanical and electronic centres of the instrument. The electronic centre is imaginary point in the instrument depending upon the positioning of transmitting and receiving components and also due to delays caused by electronic circuits. It is the point from which the instrument measures distance. Mechanical centre is the point in the instrument with respect to which the instrument is centred on the ground-point. The zero error is either added or subtracted from the measured distance, depending upon its sign.

4 GENERAL REQUIREMENTS

4.1 Each part of the instrument shall be made from materials of suitable strength and shall be suitably finished.

4.2 Coating, plating, anodizing and painting on the requisite parts shall be durable to resist discoloration, wear and rust and shall be resistant to corrosion

4.3 Optical parts shall conform to IS 988 : 1959 and shall be free from fog and moulds.

4.4 The optical parts shall be coated with the anti-reflection coating for near infrared region in accordance with 4.2.

4.5 The opto-electronic system shall be suitably sealed.

4.6 The case of the instrument shall be made of fibreglass and shall be internally fitted with cushioning material for protecting the instrument and accessories from shock and vibration, etc. Space shall be made in the cushioning material for accommodating the instrument, battery and prisms, thermometer, barometer, lens cleaning brush, etc.

5 FUNCTIONAL REQUIREMENTS

5.1 Key board switches shall be membrane/touch type or electromechanical type and shall be fool proof.

5.2 Internal opto-electronic part shall be sealed in such a way that dust particles, moisture and excessive heat do not affect the function of these parts.

5.3 The colour of key board and functional switches shall be different from that of the main instrument to enable the operator for easy identification in poor light condition.

5.4 The markings on the switches shall be easily readable even in insufficient light condition.

5.5 When the instrument is connected to the battery the indicating lamp or ready light shall work immediately.

5.6 The instrument shall either be an integrated system with theodolite or only the distance measuring one. In the latter case, the instrument shall either be supplied with yoke for independent mounting on tripod or with suitable adaptor for mounting on the desired theodolite.

5.7 The instrument shall be capable of measuring distance even with slight interruption of infrared beam.

6 TECHNICAL REQUIREMENTS

6.1 The instrument shall meet the following technical specifications.

6.1.1 Range

Range	In Poor Weather Condition	Normal Condition	Excellent Condition
With 1 Prism	500 m	1 000 m	1 500 m
With 3 Prisms	800 m	1 500 m	2 000 m

a) Poor Weather Condition

Strong haze with visibility up to about 3 km or very bright sunlight with severe heat shimmer.

b) Normal Weather Condition

Light haze with visibility up to about 15 km or moderate sunlight with light heat shimmer.

c) Excellent Weather Condition

Overcast sky, no haze, visibility up to about 30 km, no heat shimmer.

6.1.2 Standard Deviation (Accuracy) : $\pm (5 \text{ mm} + 5 \text{ ppm})$.

6.1.3 Display to be Provided : Seven digits LCD/LED.

6.1.4 Mode of Distance Display : Metres.

6.1.5 Mode of Angle Display : Degrees, minutes, seconds.

6.1.6 Least Count for Distance Display : 1 mm.

6.1.7 Operating Temperature : 20° to $+55^{\circ}\text{C}$.

6.1.8 Atmospheric Correction : Provision for applying atmospheric correction to be made in display.

6.1.9 Prism Constant Correction : Prism constant to be supplied by the manufacturer and the provision for applying prism correction to be made in display.

6.1.10 Indication for Alignment on Target (Prism) : Signal strength meter/audio sound to be provided.

6.1.11 Power Supply : Rechargeable 12 V, 2 Ah to 7 Ah Ni-Cd battery pack and provision to use 12 V vehicle battery also to be made.

6.1.12 Tilting Angle on Yoke : Up to $\pm 45^\circ$ and to be able to measure with the prism supplier in tilting condition.

6.1.13 Sighting Telescope (for use with yoke) : Erect image, 8 $\times$ magnification.

6.1.14 Automatic Attenuation : Provision to be made for strong signals.

6.1.15 Self Checking/Test Mode : Provision to be made in the instrument for test mode indications.

6.1.16 Automatic Power Cut Off : Provision to be made when battery starts discharging.

6.1.17 Battery Check : Provision to be made.

6.1.18 Battery Charger : Suitable for battery supplied.

6.1.19 Angle Input : Up to 360°.

6.1.20 Measuring Mode : Slope and horizontal distances and elevation-difference.

6.1.21 Scan : Provision to be made.

6.1.22 Mounting : Provision with yoke and also with adapter on theodolite, to be used by the purchaser.

7 ACCESSORIES

7.1 The following accessories shall be supplied with each instrument:

<i>Accessory</i>	<i>No.</i>
a) Carrying case	1
b) Instrument of battery cable	1
c) Instrument to external (vehicle) battery cable	1
d) External attenuator screen	1
e) Rain and dust cover	1
f) Yoke with sighting telescope	1
g) Telescopic tripod for instrument (with plumb bob)	1
h) Tribrach for instrument	1
j) Adaptor for instrument	1
k) Battery 12 V, between 2 Ah to 7 Ah	1
m) Charger for battery	1
n) Single triple prism assembly	1
p) Telescopic tripod for prism (with plumb bob)	1
q) Tribrach for prism (with optical centring device)	1
r) Adaptor for prism	1

<i>Accessory</i>	<i>No.</i>
s) ppm chart (device)	1
t) Instruments operation manual	1
u) Tool kit	1 Set
v) Thermometer (degree celsius)	1
w) Barometer (mb/mm)	1
x) Atmospheric correction graph	1
y) Lens cleaning brush	1

8 TESTS

8.1 The instrument shall be tested to comply with the requirements laid down in 4, 5 and 6.

8.2 The instrument shall be tested for improper fitting, missing components and damage or deterioration to various parts which shall not be allowed.

8.3 The instrument shall be subjected to test mode operation and it shall be ensured that proper display/indication, as laid down in the operation manual, is seen.

8.4 Collimation Test

The instrument shall be subjected to this test by placing the reflector at short distance, say, 100 m, and it shall be ensured that a return signal is received when the telescope cross wires are sighted on the prism. Only slight turn of horizontal and vertical slow motion screws should be able to optimize the return signal for measuring. If not, collimation error shall exist which shall be adjusted in accordance with the procedure laid down in the operation manual. It shall be ensured that this adjustment is possible.

8.5 Climatic and Environmental Tests

8.5.1 Cold Test

The instrument, in non-working condition, shall be subjected to cold test at a temperature of -10°C for a period of 4 hours as specified in IS 10236 (Part 3) : 1982. After the test, there shall not be any deterioration to any part of the instrument, namely, jamming of joints and deterioration of paint, etc. The instrument shall work well after the test.

8.5.2 Dry Heat Test

The instrument, in non-working condition, shall be subjected to dry heat test at a temperature of 55°C for a period of 16 hours as given in IS 10236 (Part 2) : 1982. There shall not be any deterioration to any part of the instrument after the test namely, looseness of joints and deterioration of paint, etc. The instrument shall work well after the test.

8.5.3 Rain Test

The instrument in non-working condition, shall be subjected to this test as given in IS 10236 (Part 14) : 1986 at severity I (see 6.1). After the test, there shall not be any deterioration of any part, namely, ingress of water inside, deterioration to optical surfaces and paint, etc. The instrument shall work well after the test.

8.5.4 Vibration Test

The instrument, in non-working condition, shall be subjected to the test for frequency range of 5 to 50 Hz (see 6.1.1), displacement amplitude of 2.5 mm (Table 2) and a duration of 3 hours (see 6.1.3.2) as in IS 10236 (Part 11) : 1985 [see Table 4 (i) also]. After the test, there shall not be any deterioration to any part, namely, looseness of joints, breakage of components, etc. The instrument shall work well after the test.

8.5.5 Salt Mist Test

The instrument, in non-working condition, shall be subjected to this test as given in IS 10236 (Part 6) : 1982 at severity-1 (see 7.1). After the test there shall not be any deterioration of any part, namely, ingress of water deterioration to optical surfaces and paint, etc. The instrument shall work well after the test.

8.6 Cyclic Error

The instrument shall be subjected to this test as given in the operation manual and it shall be ensured that the error does not exist. The set up for this test, used by the manufacturer, may be used.

8.7 Range and Accuracy

The instrument shall be tested for its full range on a known base line. For this, the range shall be measured by the instrument after feeding internally the prism constant and the atmospheric correction obtained from the manual. Alternatively, the atmospheric correction may be read from chart and applied by calculations, after getting the distance. To get this correction, temperature and pressure readings at instrument and reflector stations shall be taken and mean values accepted for the chart. This corrected

distance will be slope distance which shall be converted into horizontal distance either automatically by feeding the vertical angle from the theodolite to the instrument or by calculations, using the differential height between the instrument and the reflector stations. In the latter case, the formula $C = \Delta h^2 / 2S$ shall be used, where C is the slope correction, Δh is difference between heights of instrument and reflector stations and S is the corrected slope distance. The horizontal distance shall be the corrected slope distance (S) minus slope correction C . While determining height, the height of the instrument and the reflector above the ground shall be added to the respective station heights above mean sea level. To measure height above ground, the central point of the instrument and reflector shall be taken.

The horizontal distance so obtained shall be corrected for the zero error (additive constant) of the instrument. The zero error shall be first determined by any of the methods given in Annex A. It shall be added, with proper sign to the horizontal measured distance to get the zero error corrected horizontal distance. This distance will be the representative distance obtained from the instrument for that range. Ten such values shall be obtained and mean calculated. The difference between this mean value and the known distance (range) will give the accuracy of the instrument which shall conform to the specified value. For example, the accuracy so obtained at 1 km range, shall be $\pm (5 \text{ mm} + 5 \text{ ppm}) = \pm (5 \text{ mm} + 5 \text{ mm}) = \pm 10 \text{ mm}$.

NOTE — In fact the standard deviation has been specified as $\sigma = \pm (5 \text{ mm} + 5 \text{ ppm})$ but statistically, in 66 percent (that is, majority) of the cases, the accuracy shall be 1σ , namely, this value of 10 mm, and therefore this shall be accepted as standard.

9 MARKING

9.1 The instrument shall be marked with the indication of the source of manufacture and the year of manufacture.

10 PACKING

10.1 The instrument and its accessories shall be placed in its case and suitably packed for transit. While packing, suitable cushioning materials shall be used to avoid damage during transportation.

ANNEX A

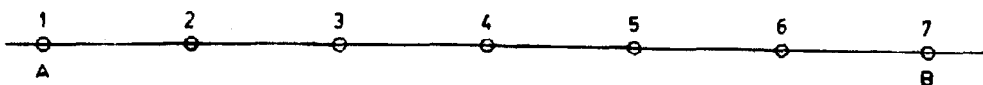
(Clause 8.7)

METHODS OF ZERO ERROR DETERMINATION

A-1 METHOD 1

A-1.1 Known Base Line

In case of a known base line (which should be more accurate than the distance measuring accuracy of the instrument) the additive constant (zero error) can be determined by measuring various sections. Such a base line may be that established with invar wires. The method is as follows:



Suppose, AB is a base line having 7 points so that there are 6 sections. Out of these 6 sections, 21 combinations of distances may be obtained, such as, 12, 13.....17; 23, 24 27; 34, 35..... 37; 45, 46, 47; 56, 57; and 67. All these distances can be computed as the value of individual sections are predetermined by invar wires or any other better means.

A-1.1.1 While measuring each of 21 sections, about 10 observations will be taken with the EDM instrument which will be slope distances. The mean shall be taken. The mean slope distance shall then be corrected for meteorological conditions. In case there is provision of applying meteorological correction automatically in the instrument, the same may be done and then one will get 10 corrected slope distance for a section. The mean of corrected slope distance will be taken and the same converted into horizontal distances, that is, in the same term as the sections of the base line are known. This will be the accepted horizontal distance for each section.

A-1.1.2 Thus 21 measured values of 21 sections are obtained with the EDM instrument and their differences with corresponding known values will give 21 values of zero error. The mean of 21 values will be accepted as zero error (additive constant) for that instrument.

A-2 METHOD 2

A-2.1 Unknown Base Line

Suppose AB is as known base line in which there are n unknown unequal sections. All the sections

shall be measured with the instrument in the same way as mentioned in Method 1. The zero-error shall be determined as below:

$$ZE \text{ (zero error)} = \frac{AC - \sum_{i=1}^n d_i}{n-1}$$

For better accuracy, more than 5 sections may be made in the line AB .

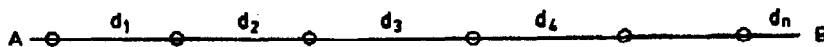
A-3 PRECAUTIONS

A-3.1 While determining zero error, the weather selected should be as normal as possible. The measurements may not be taken during noon when a lot of shimmering is expected.

A-3.2 The instrument should be used with will charged battery and all the precautions for measurement with EDM instrument, namely, their centring on ground points, collimation adjustment between the aiming head (transmitting and receiving optical system) and sighting telescope, using umbrella on instrument and reflector, etc, should be observed.

A-3.3 It may be preferred to use shorter base line having a length of 500 m or so to get almost uniform atmospheric condition during measurements.

A-3.4 The points should be properly aligned so as to be in the same straight line.



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Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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